

Exporting, Externalities, and Technology Transfer

Howard Pack

Kamal Saggi

"Vertical" international technology transfer may differ substantially from the horizontal technology transfer emphasized in the literature. In this model, a downstream firm benefits from the diffusion of knowledge it transfers to a developing country firm because diffusion increases demand for its services.



Summary findings

Developed-country purchasers of exports from developing-country industrial firms have often provided considerable technical aid to the exporting firms. Some question the benefits to both OECD and developing country firms of such transfers.

Pack and Saggi developed a model to analyze the implications of diffusion of the transferred technology to other developing country firms and the impact of the market entry of additional firms.

Surprisingly, diffusion upstream combined with entry downstream may increase the profits of both the OECD importer and its initial developing-country supplier because the diffusion increases competition both upstream and downstream. The intuition is that a firm does not necessarily lose from competition in its market so long as its buyer/supplier is also forced to behave more competitively as a result of diffusion. A limited amount of increased competition at both stages moves the two firms closer to a vertically integrated firm.

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Exporting, Externalities, and Technology Transfer

Howard Pack* and Kamal Saggi**

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Abstract

Industrial country purchasers of exports from industrial firms in developing countries have often provided considerable technical aid to firms in developing countries. Questions arise as to the benefits to both the Organisation for Economic Co-operation and Development (OECD) firms and firms in developing countries of such transfers. To address these issues we develop a model that analyzes the implications of diffusion of the transferred technology to other firms in developing countries and the impact of the entry of additional marketing firms. Surprisingly, diffusion upstream combined with entry downstream may increase the profits of both the industrial country importer and its initial developing country supplier by moving them to an approximation of the vertical integration outcome.

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*Department of Public Policy and Management, The Wharton School, University of Pennsylvania, Philadelphia, PA 19104 and the World Bank. Phone: (215) 898-0089, Fax: (215) 898-7635, E-mail: packh@wharton.upenn.edu.

**Department of Economics, Southern Methodist University, Dallas, TX 75275-0496. Phone: (214) 768-3274, Fax: (214)-768-1821, E-mail: ksaggi@mail.smu.edu.

1. Introduction

The rapid growth of a few Asian countries such as Korea and Taiwan, China was associated with an even more rapid growth in exports. This association has raised the question of whether exports, in addition to providing a source of demand and the foreign exchange for capital goods and intermediates, has also generated additional supply augmenting effects. Does the correlation of exports and rapid gross domestic product (GDP) growth imply that exports confer some productivity augmenting effect that is not generated by sales in the domestic market? It is now well documented that during their initial growth spurts both manufacturers in Korean and Taiwan, China benefited from technology transfer by industrial country purchasers of their products (Rhee, Ross-Larson, and Pursell 1984). If these transfers cost the developing-country manufacturer less than the benefits they provide, they constitute one potential channel through which exporting may confer an externality.¹ Unlike the externalities envisioned in many endogenous growth models, it is neither physical investment nor education that generate an externality but the size of exports and the interaction with purchasers. This process could help to explain the result in many cross-country regressions that exports appear to be a correlate of high growth rates of GDP per capita, though such studies do not establish the causal mechanism. (Levine and Renelt 1992).²

A related issue that can be addressed more fully by considering externalities is the recent discussion of the role of total factor productivity (TFP) growth in explaining the high growth rates of Korea, Taiwan, China and a few other countries. In particular, Kim and Lau (1994) find virtually no TFP growth in countries such as Korea and Taiwan, China. One explanation they offer is that improvement in physical TFP (say yards of cloth per loom and unskilled worker) does not translate into domestic gains in income as foreign suppliers of knowledge or machinery fully price their products, extracting the entire economic benefit for themselves, leaving the recipient country with only the normal return on labor and capital. The lack of inframarginal benefits depends on the absence of technological diffusion. This paper suggests a model in which significant benefits may in fact accrue to local firms who are the indirect beneficiaries of such transfers. Whether the Kim and

¹ The cost of the transfer will include any payment obtained by the transferor whether as an explicit charge or via a reduced price for the output plus any additional personnel and other costs borne by the transferee.

² A recent paper of Clerides, Lachs, and Tybout (1998) attempts to measure externalities from exporting. Our model provides some of the theoretical underpinning explaining why such externalities may occur.

Lau results about the TFP growth having been zero are correct is an empirical issue. But their basis for explaining their result is dependent on a specific set of assumptions about the behavior of firms.

There are several puzzling aspects to the process of technology transfer undertaken by importers in industrial countries. Most importantly, why do they provide such knowledge given that it could diffuse to other local firms (say via worker mobility) who may then sell to other importers in industrial countries. The types of knowledge transmitted include product designs, improvements in production technology including adjustments in machinery settings, and advice on packaging and instruction materials. When these transfers occurred in the 1960s and 1970s, property rights were very weak in all of the Asian countries and the types of knowledge transferred are in any regime of intellectual property rights, difficult to protect. In such situations, the firms in industrial countries are providing a form of general training that is highly transferable to other firms (Becker 1964). While it is possible that the recipients of knowledge transfers implicitly pay for it by receiving lower prices for their products, we develop an alternative view of why technology suppliers may offer their knowledge without extracting payment for the transferable component.

We thus emphasize the analysis of technology transfers that are vertical, conforming to the growing amount of trade between OECD wholesalers and retailers and manufacturers in developing countries. This contrasts with recent analyses of the horizontal aspects of technology transfers among firms that produce the same products (Ethier and Markusen 1996, Saggi 1996, Kabiraj and Marjit 1993, and Glass and Saggi 1998).

Section 2 briefly discusses the available evidence on technology transfers by OECD importers of products from developing countries and discusses the structure of these transfers. Section 3 presents a formal model of the process and section 4 offers conclusions.

2. Empirical Evidence and Overview

A substantial body of empirical evidence indicates that considerable vertical knowledge transfer from developing countries to the Asian newly industrialized countries (NICs) has occurred as OECD firms have bought part or all of the output of local firms and have sold it under the name of the purchaser (Hobday 1995). For example, companies such as Radio Shack and Texas Instruments have commissioned firms in developing countries to produce components or entire products, which are then sold under the retailer's name. Rhee, Ross-Larson, and Pursell (1984), summarizing the results of extensive interviews in Korea in the late 1970s report that

The relations between Korean firms and the foreign buyers went far beyond the negotiation and fulfillment of contracts. Almost half of the firms said they had directly benefited from the technical information foreign buyers provided: through visits to their plants by engineers or other technical staff of the foreign buyers, through visits by their engineering staff to the foreign buyers, through the provision of blueprints and specifications, through information on production techniques and on the technical specifications of competing products, and through feedback on the design, quality and technical performance of their products (p.61).

Not only manufacturing knowledge was transferred but exact sizes, colors, labels, packing materials and instructions to users. A large survey of many firms in Korea and Taiwan, China in the late 1970s found that importers maintained very large staffs based in the countries who spend considerable time with their local manufacturers (Keesing 1982). Studies in other countries such as Taiwan, China have confirmed such findings of significant technology transfer by industrial-country importers (Hou and Gee 1995). Once mastered, such knowledge is useful to other potential importers.³

To understand how externalities may arise, we construct a simple model in which an industrial-country firm may choose to engage in vertical technology transfer by outsourcing basic production to developing-country firm(s). A key feature of the model is that once the technology is transferred to an developing-country firm, some of the knowledge that is provided by the industrial-country firm may seep out to a nonaffiliated firm within the developing country.⁴ How does the possibility of such leakage affect the incentives for vertical technology transfer? Since firms in developing countries often lack the ability to successfully market their products in the industrial-country market, technology leakage in the developing-country market actually *benefits* the industrial-country firm since it increases competition among the developing-country suppliers.

However, there is a possibility that the decrease in price due to technology diffusion in the developing-country market may induce entry into marketing thereby increasing competition in the

³ We assume that the original recipients of knowledge are contractually bound to the providers of knowledge and do not violate their contract. Even if firms were tempted to violate their contract, the reputation effects would likely be severe.

⁴ This possibility has led to a concern in the United States that transfer of technology by American firms will eventually adversely affect U.S. income.

industrial-country market.⁵ Accordingly, we extend our basic model to allow for such a possibility. Increased competition in the industrial-country market may erode profits of the original industrial-country firm, but this effect may not be necessarily strong enough to dissuade the industrial-country firm from outsourcing its production. In fact, our analysis shows that diffusion of technology among developing-country producers accompanied by entry in the downstream industrial-country market may actually benefit the two original firms engaged in technology transfer. The intuition for this surprising result is as follows. In the absence of diffusion upstream and entry downstream, the two original firms are in a bilateral monopoly and they impose a pecuniary vertical externality upon each other by charging a price above marginal cost (i.e., the double marginalization problem). Diffusion upstream brings the developing-country price closer to marginal cost and benefits the industrial-country firm. Entry downstream brings the downstream price closer to marginal cost and benefits the original developing-country firm. As a result, as long as the competition resulting from diffusion upstream and entry downstream is not too severe, both firms gain from diffusion that leads to entry in the downstream market.⁶ Note that if the industrial-country firm and the developing-country supplier are vertically integrated, diffusion harms the industrial-country firm since under vertical integration, the industrial-country firm can obtain the upstream good at marginal cost. The implication of this result is that fully integrated multinational firms may be more averse to technology diffusion than firms that are involved in international arms length arrangements. The above result may also shed some light on policies that favor licensing and other arms length arrangements of technology transfer relative to foreign direct investment.

⁵ Panasonic, to name one firm, is largely a marketing company that has had remarkable success in penetrating the U.S. market after Japanese firms mastered technology originally developed by American firms. There are numerous instances of developing-country marketing firms arising, which purchase local products and sell them in the industrial countries. For example, by 1978, Korea had over 2,000 trading companies (Keesing 1982). Taiwan's experience has been similar.

⁶ Of course, in the absence of downstream entry, diffusion hurts the original developing-country firm, given that it has accepted an outsourcing contract. However, one must be careful here. Suppose diffusion does not lead to downstream entry. Does it necessarily hurt the original developing-country firm? The answer is that given the industrial-country firm's decision to outsource is not affected, it does. But it is entirely possible that in the absence of the possibility of diffusion, the industrial-country firm is unwilling to transfer technology.

3. Model

Our basic model is a three-stage game involving one industrial-country firm and two developing-country firms.⁷ In the first stage, the industrial-country firm (labeled by 0) chooses to outsource production to a subset of the developing-country firms. The profits that the industrial-country firm can earn by producing in the industrial-country market are normalized to zero. The industrial-country firm is willing to take a chance on transferring a technology over which it could conceivably lose control as it perceives itself to have a complementary asset (marketing skills) in the absence of which sales in the industrial-country home market are not possible. Successful outsourcing requires transfer of technology to the developing-country firm(s) and involves a per firm fixed cost of I that may be substantial (Teece 1977). Let θ denote the share of this fixed cost that is borne by industrial-country firm. It results in the acquisition of technology by developing-country firm(s) that allows them to produce a good that can be sold in the industrial-country market by industrial-country firm. In the next stage of the game, each developing-country firm decides whether or not to accept the outsourcing deal. In the final stage, the industrial-country firm obtains the basic product from its developing-country partner(s) and then markets the product in the industrial-country market. The output of the developing-country firm and the marketing effort of the industrial-country firm are complements—one unit of output requires one unit of marketing.

Complicating the decision of both the industrial-country firm and the developing-country firms is the possibility of technology diffusion: once the technology is transferred to a developing-country firm, it may leak out to the other firm. Let p denote the probability that the technology leaks out to the other developing-country firm.⁸ All firms recognize the possibility of interfirm technology diffusion and take this possibility into account while making their decisions. Technology diffusion within the developing-country economy is incomplete: post diffusion, the marginal cost of production of a firm which is not directly involved in outsourcing equals $c_2 > c_1$. The idea behind this assumption is that without the explicit involvement of the industrial-country firm, developing-country firms can achieve

⁷ Since we wish to focus on the transfer of technology and not on its generation, we assume that the technology is patented by a single industrial-country firm. We allow for potential competition in the industrial-country market later.

⁸ This may occur as a result of labor movement or the informal interchange of knowledge between managers and workers.

only a partial understanding of the technology as many of the elements are not codified but are part of the informal knowledge of the industrial-country firm that remains within the firm's possession (Nelson and Winter 1982). Upon technology adoption, the developing-country firms compete in prices and the higher cost firm is limit priced out of the market so that price in the upstream market drops to $c_2 > c_1$.

Before proceeding further, two different cases need to be considered. In the benchmark model, successful technology diffusion in the developing-country market does not pose any threat of potential entry in the industrial-country market. In this case, the second developing-country firm must also hire the original industrial-country firm as a marketing agent. The alternative case is where heightened competition in the developing-country market may induce the entry of an additional marketing firm.⁹ In this scenario, competition prevails in both markets: developing-country firms compete in the product market whereas the industrial-country firm and the second marketing firm compete at the marketing stage. We first consider the benchmark model.

3.1 Benchmark Model

In order to solve for a subgame perfect Nash equilibrium, we solve the game by backward induction. In the final stage of the game, the industrial-country firm markets the output of the upstream developing-country producer(s). At this stage, the number of developing-country suppliers is given. Recall that if there are multiple developing-country suppliers, they compete with each other in prices.

Let the demand curve facing the industrial-country firm be given by $p(q)$. Let w denote the price of the good supplied by the developing-country firm(s) and m_0 denote the industrial-country firm's marginal cost of marketing. Taking w as given, the industrial-country firm decides on how much output to sell in the industrial-country market. Therefore, the industrial-country firm is a monopolist whose marginal cost of providing the good to industrial-country consumers equals $w + m_0$. Facing the

⁹ This additional marketing firm could even be a developing-country firm. The crucial point is that only a large enough increase in demand for marketing, makes it worthwhile to pay the fixed cost needed to be able to provide this service.

demand curve $p(q)$ in the industrial-country market, the industrial-country firm solves the following problem:

$$\text{Max } (p(q) - w - m_0) q$$

Let the optimal solution to the above problem be denoted by $q^m(w)$.¹⁰

Consider the decision of those developing-country firms that are approached by the industrial-country firm. First note that since price competition prevails in the upstream developing-country market, if both developing-country firms accept the outsourcing contract, upstream equilibrium price will equal marginal cost c_1 . Since all firms foresee the nature of the competition at the next stage, given that one developing-country firm accepts the offer, the second developing-country firm will prefer to take its chances regarding costless technology diffusion rather than incur any part of the cost $(1 - \theta)I$. Thus, an outsourcing deal that does not compensate developing-country firms for their share of the costs of technology transfer is not accepted by more than one firm. The question then becomes whether it is ever in the interest of the industrial-country firm to outsource production to both developing-country firms by bearing the entire (per firm) fixed cost I . In other words, if side-payments are possible among firms, by bearing the entire fixed cost I itself, the industrial-country firm can create an alternative developing-country supplier with probability one or it may choose to take the chance that the technology will leak out to the other developing-country firm with probability p , where $0 < p < 1$.¹¹ To explore the trade-off between outsourcing a single versus multiple firms, we first need some notation.

Let the optimal price charged by an upstream developing-country monopolist (denoted by 1) be given by w_1 . Clearly, w_1 is obtained by solving the following problem:

$$\text{Max}_w q^m(w)(w - c_1)$$

¹⁰ Note that the dependence of q^m on m^0 is suppressed for expositional ease.

¹¹ An alternative but equivalent interpretation is that technology diffuses over time and p is the discount factor which applies to profits earned post diffusion. Also note that, the key assumption here is that while the transfer between the industrial-country firm and a second developing-country firm entails the cost I , the second developing-country firm may learn from the first developing-country firm at a lower cost once that technology has been successfully absorbed by that first developing-country firm. Demonstration effects or movement of workers between the firms may contribute to such learning.

where $q^m(w)$ is the derived demand curve facing firm 1. Maximized profits for each firm i (gross of fixed costs) where $i = 0, 1$ equal

$$\pi_1 \equiv (w_1 - c_1)q^m(w_1) \quad (3.1)$$

$$\pi_0(w_1) \equiv (p(q^m(w_1)) - m_0)q^m(w_1) \quad (3.2)$$

Upon technology diffusion, the two developing-country firms become competitors in the upstream developing-country market and the price falls to $c_2 < w_1$. It is clear that the industrial-country firm benefits from the entry of an alternative developing-country supplier due to diffusion. The industrial-country firm can also create a second developing-country supplier rather than depend upon the vagaries of diffusion. However, to do so, it must bear additional full costs of technology transfer. Thus, while making its outsourcing decision, firm 0 faces the following decision problem: it can outsource two developing-country firms by paying the fixed cost $2I$ and face a marginal cost of output equal to c_1 or it can outsource to only one of them, pay a lower fixed cost of only θI but pay a higher marginal cost (w_1 if technology does not leak out to the second developing-country firm and c_2 if it does). Let the net profits of the industrial-country firm under the first strategy be given by

$$v_0(2) = \pi_0(c_1) - 2I$$

where $\pi_0(c_1)$ denote industrial-country firm 0's profits when it buys the upstream good at price c_1 . Under exclusive outsourcing, its net expected profits are given by

$$v_0(1) = (1 - p)\pi_0(w_1) + p\pi_0(c_2) - \theta I = \pi_0(w_1) + p(\pi_0(c_2) - \pi_0(w_1)) - \theta I$$

Therefore, the industrial-country firm chooses to outsource only firm 1 iff $v_0(1) > v_0(2) \Leftrightarrow I > I^*$ where

$$I^* \equiv \frac{[\pi_0(c_1) - \pi_0(w_1)] - p[\pi_0(c_2) - \pi_0(w_1)]}{2 - \theta}$$

Hence, a high enough fixed cost of outsourcing implies that only one of the developing-country firms will be outsourced.¹² This completes the conditions required for outsourcing of a single developing-country firm to be an equilibrium. Note that single developing-country firms always accept an outsourcing deal since it is assumed they are unable to sell in the industrial-country market without technology and marketing skills of the industrial-country firm.

The first main point of this paper can be seen from noting that since $\pi_0(c_2) > \pi_0(w_1)$, $v_0(1)$ increases in p : technology diffusion between developing-country manufacturers benefits the industrial-country purchaser.¹³ The decision to transfer knowledge by industrial-country importers is fully consistent with profit maximization even when it is understood that the benefits of the knowledge provided are not fully appropriated by the recipient in the developing country. We next extend the model to allow for the possibility of downstream entry to determine whether this insight is robust to the possibility of potential downstream competition.

3.2 Potential Entry Into Marketing

Suppose there exists a potential entrant, firm 3, who can successfully market in the industrial-country market provided the price in the industrial-country market is sufficiently high. Firm 3's marginal cost of marketing is given by m_3 . Assume that $p(q^m(w_1+m_0)) < w_1+m_3$ so that firm 3 cannot profitably enter the market so long as the upstream price equals w_1 and the downstream price equals $p(q^m(w_1))$. Technology diffusion in the developing-country market lowers the price of the good produced by developing-country firms from w_1 to c_2 . Consequently, firm 3 may now find it profitable to provide marketing services if firm 1 continues to charge the monopoly price $p(q^m(c_2+m_0))$. The

¹² Teece (1977) and others have shown that technology transfer costs are quite large, as much as 25 percent of total project costs for a multinational establishing a wholly owned subsidiary. For a subcontractor where the technology supplying firm has no control over the staff, the initial fixed cost of transfer is likely to be considerably greater.

¹³ There is an interesting if imperfect analogy between this and the Prebisch-Singer argument that technical diffusion within developing countries leads to a deterioration in their terms of trade relative to developed countries because of greater competition in the sectors undergoing such diffusion.

industrial-country firm 0 can deter entry by lowering the price to $c_2 + m_3$ thereby enjoying a markup of $m_3 - m_0 < p(q^m(c_2 + m_0)) - m_0$.¹⁴

We now address the consequences of technology diffusion on the original participants in technology transfer: the industrial-country firm 0 and developing-country firm 1. First consider the fate of developing-country firm 1. The key parameters that determine whether developing-country firm 1 gains or loses from technology diffusion are c_2 and m_3 . When c_2 is close enough to w_1 and m_3 is close to m_0 , developing-country firm 1 experiences a large increase in sales and suffers only a small reduction in price as a result of technology diffusion. As a result, its profits increase because of technology diffusion. In effect, it is as if the ex post elasticity of demand faced by the firm in the noncompetitive market is high.

This result may help explain in retrospect why some of the policies of the Japanese and Korean governments may have succeeded though the rationale provided here may not have been understood ex ante by policymakers. In Japan, dissemination of knowledge to all firms who could benefit from it, without any additional fees, was a condition for the approval of foreign technology licensees (Ozawa 1974, Nagaoka 1989). In Japan and Korea, cost reducing incentives that reduced m_3 , were provided for domestic firms that became international marketing or trading companies. The potential private benefits of a low marginal cost of marketing to the first developing-country firm that is outsourced may be thought of as an externality to be captured by precisely the type of interventions undertaken by the Ministry of International Trade and Investment (MITI) in Japan and the Economic Planning Board in Korea (Jones and SaKong 1980, Nagaoka 1989, and Ozawa 1974).

As was noted above, when the emergence of a new marketing agent is infeasible, firm 0 necessarily benefits from technology diffusion. What happens when there is a potential entrant into marketing? Technology diffusion now creates a trade-off for the industrial-country firm 0. It creates competition among suppliers while it invites entry into the downstream industrial-country market.

¹⁴ Note that a fixed cost of entry at the marketing stage is easily handled. Suppose M denotes the fixed entry cost for firm 3. In this context, we need to merely define a limit price p_L which makes entry unprofitable for firm 3. This price would exceed firm 3's marginal cost whenever $M > 0$ and is defined by $\pi_3(p_L) = M$, where $\pi_3(p_L)$ denotes firm 3's profits as a monopolist if it successfully undercuts firm 0's price and captures the entire downstream market by charging a price $p_L - \epsilon$.

The industrial-country firm 0 may still benefit from technology diffusion if the demand in the final goods market is sufficiently elastic and the degree of competition downstream is weak. In the absence of potential entry into marketing, the interests of industrial-country firm 0 and developing-country firm 1 necessarily clash. Surprisingly, downstream entry can tie the interests of the two together—they both could benefit from technology diffusion. As noted in the introduction, the intuition for this result is that diffusion upstream coupled with entry downstream reduces the extent of the vertical externality between firm 0 and firm 1 by moving prices closer to marginal cost in both markets. Note that if the developing-country firm 1 were a fully owned subsidiary of industrial-country firm 0, the vertically integrated firm purely loses from diffusion since downstream entry reduces profits. This suggests that multinational firms that operate wholly owned subsidiaries in developing countries would be more averse to technology diffusion than those firms that have arms length arrangements with developing-country firms.¹⁵

Next, we explore the properties of the equilibrium with the help of a linear demand example.

3.3 Example 1

Suppose the demand curve in the downstream industrial-country market is given by

$$P = A - q$$

We only consider the case with potential entry since in the other case, it is clear that the industrial-country firm 0 benefits from technology diffusion whereas the developing-country firm 1 does not. Derived demand for developing-country firm 1's output is given by

$$q^m(w) = \frac{A - w - m_o}{2}$$

Given the above demand curve, developing-country firm 1 chooses w to maximize

¹⁵ This result may help explain why many developing countries have preferred licensing and other arms length means of technology transfer to direct investment: technology may be more likely to diffuse in the host country under licensing, etc.

$$\pi_1 \equiv (w - c_1) \frac{A - 2 - m_0}{2}$$

which yields

$$w_1 = \frac{A - m_0 + c_2}{2} \quad (3.3)$$

Using the above we have

$$\pi_1 = (w_1 - c_1)q^m(w_1) = \frac{[A - m_0 + c_1]^2}{8} \quad (3.4)$$

and

$$\pi_0 = (A - q^m(w_1) - m_0 - w_1)q^m(w_1) = \frac{[A - m_0 - c_1]^2}{16} \quad (3.5)$$

After diffusion in the developing country, and with potential entry in the industrial-country market, prices equal c_2 and $m_3 + c_2$, respectively. This implies

$$\pi_0^d \equiv m_3(A - m_3 - c_2) \quad (3.6)$$

and

$$\pi_1^d \equiv (c_2 - c_1)(A - m_3 - c_2) \quad (3.7)$$

Therefore, technology diffusion increases firm 1's expected profits iff $\pi_1 < \pi_1^d$. Further insight can be gained by imposing the normalization $c_1 = m_0 = 0$. Using equations (3.6) and (3.7), the preceding inequality simplifies to

$$A^2 < 8c_2(A - m_3 - c_2)$$

The above inequality is illustrated as curve A in the (c_2, m_3) space in figure 1. Along Curve A, $\pi_1 = \pi_1^d$ so that developing-country firm 1's profits are unaffected by technology diffusion. Above this curve, firm 1 loses from diffusion whereas below it, it gains. Note that as the marginal cost of the potential developing-country entrant increases, the competition that results from technology diffusion does not affect industrial-country firm 0's profits much. On the other hand, if even a small drop in upstream price is sufficient to induce entry in the downstream market, developing-country firm 1

gains from technology diffusion. Thus, for industrial-country firm 0's fate to be unaffected by technology diffusion it must be that m_3 increases with c_2 , the reason curve A is upward sloping.

Similarly, diffusion benefits industrial-country firm 0 iff $\pi_0^d > \pi_0$. Using equations (3.5) and (3.6) and imposing the normalization $c_1 = m_0 = 0$, we can rewrite the preceding inequality as

$$A^2 < 16m_3(A - m_3 - c_2).$$

In figure 1, Curve B plots the locust of $\pi_0^d = \pi_0$. Along this curve, industrial-country firm 0's profits are unaffected by technology diffusion. Above this curve, diffusion benefits firm 0 whereas below the curve, it hurts firm 0. By logic similar to that used above, for industrial-country firm 0's profits to be unaffected by diffusion, m_3 must increase with c_2 .

The two curves partition the space into four regions. In region C, both firms lose from technology diffusion. In this region, both c_2 and m_3 are small so that drop in the price of the upstream (downstream) good hurts developing-country firm 1 (industrial-country firm 0) more than the reduction in the marginal cost in the downstream (upstream) market. In region D, industrial-country firm 0 gains from diffusion while developing-country firm 1 loses: c_2 is low here and m_3 is high so that upstream price drops substantially whereas downstream price is not affected much. In region E, both m_3 and c_2 are high and *both* firms gain from technology diffusion: small increase in competition at both stages helps reduce the vertical externality. Finally, in region F, industrial-country firm 0 loses from diffusion whereas firm 1 actually gains since a small reduction in upstream price results in a large reduction in downstream price (since m_3 is large relative c_2).

4. Discussion

In the basic model we assumed Bertrand competition in both upstream and downstream market. As a result, no actual entry takes place in equilibrium since potential entrants are limit priced out of the market. How do the results of the basic model change if actual entry takes place? We next assume Cournot competition on both markets to allow for actual entry to take place in equilibrium.

4.1 Example 2

Since equilibrium in the absence of diffusion and entry has already been derived in Example 1, we now restrict attention to the case where entry takes place in both markets. Let the output marketed by firm j be given by q_j where $j = 0, 3$. The demand curve in the downstream market is given by

$$p = A - q_0 - q_3.$$

Profit function for downstream industrial-country firm j is given by

$$\pi_j^C = (A - q_j - q_{-j} - m_0 - p^u)q_j,$$

where $-j$ denotes the rival downstream firm and p^u denotes the price in the upstream developing-country market. The first order condition for firm j is easily derived

$$\frac{\partial \pi_j^C}{\partial q_j} = -2q_j + A - q_{-j} - m_0 - p_u.$$

Solving the first order conditions above yields the equilibrium output levels of the downstream industrial-country firms as a function of the price in the upstream market:

$$q_j = \frac{A - 2m_j - p_u + m_{-j}}{3}. \quad (4.1)$$

Adding the above two equations, yields the demand curve facing the upstream developing-country firms:

$$p^u = A - \frac{m_3}{2} - \frac{m_0}{2} - \frac{3Q}{2},$$

where Q denotes the total quantity demanded by the downstream firms when upstream price equals p^u . The two upstream developing-country firms choose q_1 and q_2 noncooperatively to maximize their respective profits

$$\pi_i^C = \left[A - \frac{m_3}{2} - \frac{m_0}{2} - \frac{3q_i + 3q_{-i}}{2} - c_i \right] q_i, \quad (4.2)$$

where $I = 1, 2$ and $-i$ denotes the rival upstream firm. Standard calculations yield

$$\frac{\partial \pi_i^C}{\partial q_i} = -3q_i + A - \frac{m_3}{2} - \frac{m_0}{2} - \frac{3q_{-i}}{2} - c_i.$$

Solving the two first order conditions yields the equilibrium outputs of the two firms

$$q_i = \frac{A - m_3 - m_0 + 2c_{-i} - 4c_i}{9},$$

and the equilibrium price in the upstream developing-country market

$$p^{u*} = \frac{2A - m_3 - m_0 + 2c_2 + c_1}{6}.$$

This equilibrium upstream price can be substituted back into the appropriate equations to derive equilibrium profits of the two upstream developing-country firms

$$\pi_i^{C*} = \frac{(2A - m_3 - m_0 + 2c_{-i} - 4c_i)^2}{18},$$

as well as the equilibrium quantities of production of the two downstream industrial-country firms

$$q_j^* = \frac{4A + 7m_{-j} - 11m_j - 2(c_2 + c_1)}{18},$$

as well as their profits, which in equilibrium, are just square of the above quantities:
 $\pi_j^{C*} = (q_j^*)^2.$

We are now in a position to consider the effect of technology diffusion and entry into marketing on the profits of the firms involved in the original outsourcing deal. Figure 2 plots the change in profits of firms 0 and 1 before and after technology diffusion. Just as in figure 1, the two curves in figure 2 divide the parameter space into four regions, which are interpreted as before. Thus, the nature of market competition is not critical for our results.

5. Conclusion

Much empirical evidence indicates that downstream industrial-country buyers transferred technology to developing-country firms, which helped them export to industrial-country markets. In this paper, we provide a simple model that captures that process. Our results indicate that “vertical”

international technology transfer may differ substantially from the horizontal technology transfer emphasized in the literature. In our model, a downstream industrial-country firm actually benefits from the diffusion of the knowledge it transfers to a developing-country firm since diffusion increases demand for its services. This argument survives, with qualification, for a model in which additional upstream entry may invite downstream entry, and which increases competition for the original supplier of technology. More surprisingly, the two firms involved in the original technology transfer may benefit from diffusion since it increases competition in both the upstream as well as the downstream market. The intuition is that a firm does not necessarily lose from competition in its market so long as its buyer/supplier is also forced to behave more competitively as a result of diffusion. This result is possible because of the original distortion that exists in the vertical relationship: a limited amount of increased competition at both stages moves the two firms closer to a vertically integrated firm. An immediate implication of this result is that industrial-country firms that are vertically integrated with their developing-country suppliers cannot benefit from technology diffusion. Thus, if they can help slow down diffusion to other developing-country firms (say through restricting labor turnover), they are more likely to do so than firms that deal at arms length with their developing-country suppliers.

Our analysis has some implications for the recent discussion of the role of TFP growth in explaining the rapid growth of Korea and Taiwan, China. As noted earlier, some authors, for example, Kim and Lau (1994), argue that developed country importers may obtain all the rents that accrue from learning by offering lower prices to developing-country manufacturers. The preceding analysis implies this is not necessary. The simplest model suggests that the costs to developing-countries falls because of technology diffusion, supporting the Kim-Lau interpretation. However, when entry of an additional marketing firm is allowed, the profits of the original developing-country firm may actually increase. Thus, the view that the potential rents from technology diffusion were all appropriated by industrial-country firms, depends on the response of local agents, particularly whether managers and workers supply other producing firms with relevant knowledge and whether domestic marketing firms arise, perhaps with government support. Case studies demonstrate that many marketing firms did emerge in both Korea and Taiwan, China (Levy 1989). In the case analyzed here of vertical transfers (that were quantitatively important during the early period of industrialization in Korea and Taiwan, China) it is very likely that the developing-country firms indeed benefited. If zero total factor productivity growth is not to be viewed as a statistical artifact, behavioral explanations other than monopsony power by industrial-country firms needs to be offered.

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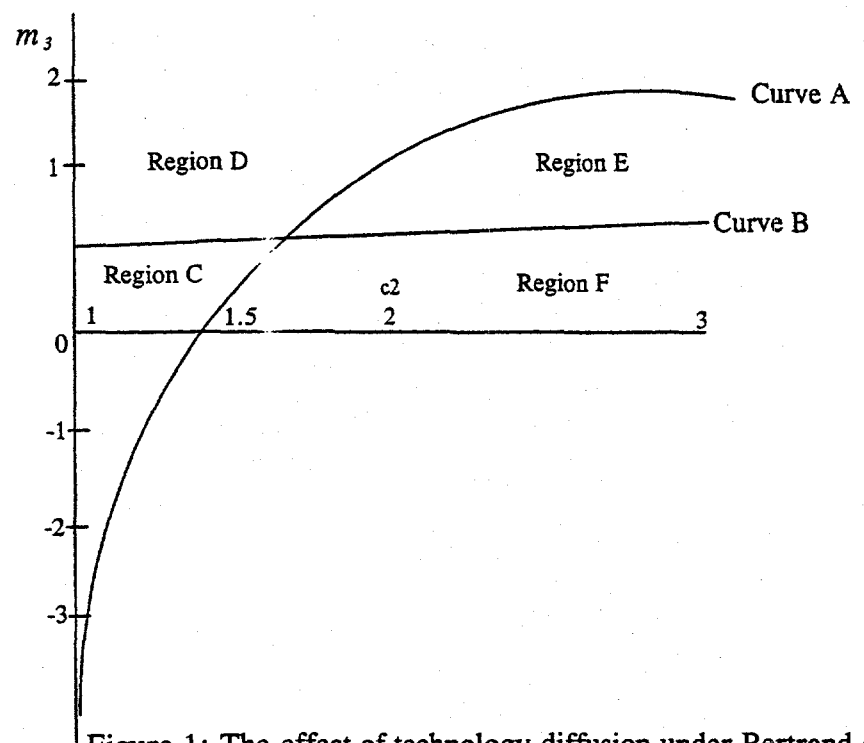


Figure 1: The effect of technology diffusion under Bertrand competition

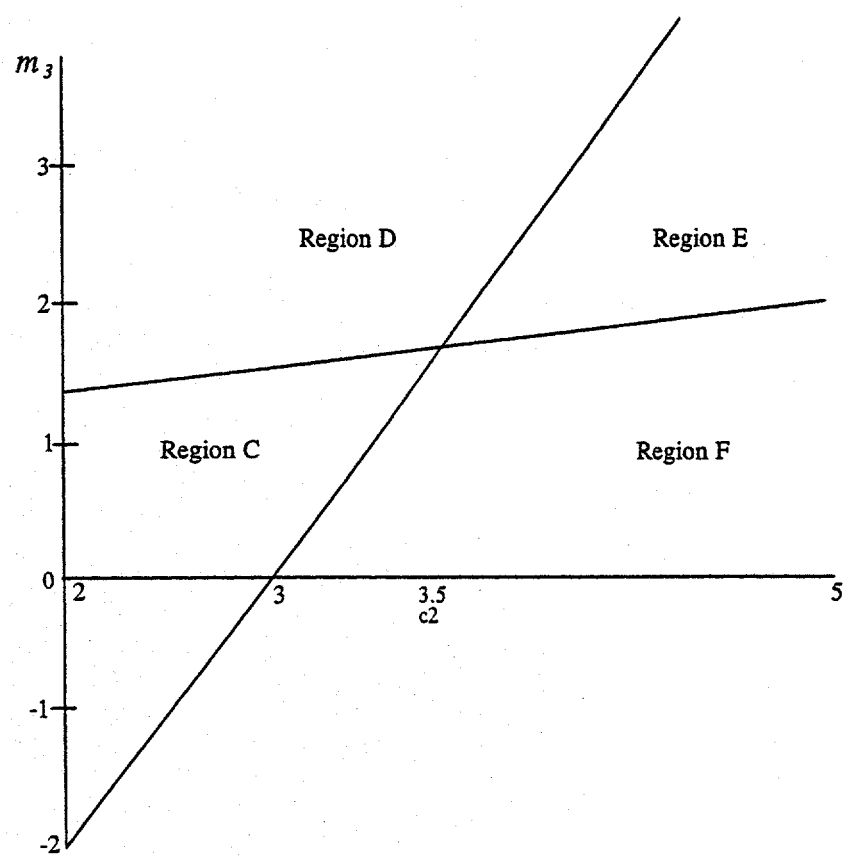


Figure 2: The effect of technology diffusion under Cournot competition.

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